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For

A METHOD OF MAKING A MICROELECTRONIC ASSEMBLY

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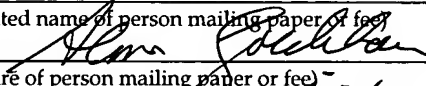
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A METHOD OF MAKING A MICROELECTRONIC ASSEMBLY

BACKGROUND OF THE INVENTION

1). Field of the Invention

[0001] This invention relates to a method of making a microelectronic assembly.

2). Discussion of Related Art

[0002] Integrated circuits are usually manufactured in and on semiconductor substrates that are subsequently “diced” or “singulated” into individual microelectronic dies. Interconnection elements are often formed on a surface of each microelectronic die before the microelectronic dies are singulated.

[0003] The interconnection elements are then placed on substrate terminals of a carrier substrate. The entire assembly is then usually placed in a reflow oven which melts the interconnection elements. Subsequent cooling of the interconnection elements causes attachment of the interconnection elements to the substrate terminals. The interconnection elements are thus soldered to the substrate terminals. A solder flux is usually provided to remove metal oxides from the interconnection elements while being soldered. The solder flux is subsequently washed out.

[0004] When an integrated circuit in such a die is operated, the integrated circuit generates heat which spreads to the remainder of the microelectronic die and to the substrate. The microelectronic die is usually made of silicon and the substrate of

another material, typically an organic polymer material. Differences in coefficients of thermal expansion cause differences in expansion rates of the microelectronic die and the substrate when the heat is generated by operating the circuit, or when the assembly is manufactured. The relative expansion between the microelectronic die and the substrate creates stresses that are especially large at interfaces between the interconnection elements and the substrate terminals.

[0005] An underfill material is often provided around the microelectronic die which flows into a space between the microelectronic die and the substrate under capillary action. The underfill material is then heated to a temperature and for a period of time sufficient to cure the underfill material. Curing of the underfill material hardens the underfill material. The hardened underfill material can distribute stresses due to differences in coefficients of thermal expansion, and so prevent the interconnection elements from shearing off the substrate terminals.

[0006] No-flow underfill materials are often provided to replace both the solder flux and the conventional underfill material. A no-flow underfill material can remove metal oxides when the interconnection elements are soldered and can subsequently be cured and hardened.

[0007] No-flow underfill materials typically do not have the good wetting and flow characteristics of conventional capillary underfill materials. The substrate is usually heated before the no-flow underfill material is dispensed thereon. The substrate then, in turn, heats the underfill material, which improves the wetting characteristics of the underfill material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention is further described by way of examples with reference to the accompanying drawings wherein:

[0009] Figures 1A to 1E are side views of components and apparatus that are used for a method of making a microelectronic assembly according to one embodiment of the invention;

[0010] Figure 2 is a flowchart corresponding to Figures 1A to 1E;

[0011] Figures 3A to 3E are side views of components and apparatus that are used for making a microelectronic assembly according to another embodiment of the invention;

[0012] Figure 4 is a flowchart corresponding to Figures 3A to 3E;

[0013] Figures 5A to 5E are side views of components and apparatus that are used for making a microelectronic assembly according to a further embodiment of the invention; and

[0014] Figure 6 is a flowchart corresponding to Figures 5A to 5E.

DETAILED DESCRIPTION OF THE INVENTION

[0015] A method of making a microelectronic assembly is provided. Wetting and flow characteristics of a no-flow underfill material are improved by preheating the no-flow underfill material. In one embodiment, the no-flow underfill material is preheated in a dispensing apparatus before being dispensed on a substrate. A die is then placed on the substrate, whereafter interconnection elements between the die and the substrate are reflowed and the no-flow underfill material is cured. In another embodiment, the no-flow underfill material is preheated after a die is placed on a substrate with the no-flow underfill material between the die and the substrate. In a further embodiment, a no-flow underfill material is dispensed on a die, whereafter a substrate is placed on the die with the no-flow underfill material between the substrate and the die.

[0016] Figures 1A to 1E and corresponding Figure 2 illustrate a method (200) of making a microelectronic assembly according to one embodiment of the invention.

[0017] As illustrated in Figure 1A, a substrate 10 and a dispensing apparatus 12 are provided. The substrate 10 is made of a dielectric material and has metal lines and metal planes formed therein and thereon. Substrate terminals 14 are formed on an upper surface of the substrate 10.

[0018] The dispensing apparatus 12 is filled with a no-flow underfill material. The no-flow underfill material is preheated while in the dispensing apparatus 12 to a temperature above the temperature of the substrate 10 (205). For purposes of illustration, a dashed line is provided in the drawings when a component or

components are heated. The no-flow underfill material in the dispensing apparatus 12 is typically preheated to a temperature of approximately 60°C. In other embodiments, a no-flow underfill material may be preheated to a temperature between 30°C and 120°C. The purpose of preheating the no-flow underfill material is to improve its wetting and flow characteristics. In general, the viscosity of the no-flow underfill material is lowered and its ability to adhere to surfaces is increased when it is heated.

[0019] As illustrated in Figure 1B, the preheated no-flow underfill material, represented with reference numeral 16, is subsequently dispensed onto an upper surface of the substrate 10 (210). The no-flow underfill material 16 is typically at approximately 60°C and the substrate 10 at approximately 22°C. There is thus a temperature difference of approximately 38°C between the no-flow underfill material 16 and the substrate 10. In another embodiment, the temperature difference may be at least 10°C. Because the no-flow underfill material 16 is heated, it adheres and spreads easily over an upper surface of the substrate 10 and the substrate terminals 14.

[0020] Figure 1C illustrates further construction of the microelectronic assembly. A microelectronic die 18 is provided and is held by a chuck 20. An integrated circuit is formed in the microelectronic die 18 and a plurality of interconnection elements 22 are formed on terminals on a lower surface of the microelectronic die 18. In the present example, the interconnection elements 22 are formed by a process generally known as controlled collapse chip connect (C4). Interconnection elements

22 are made of metals or metal alloys. Examples of metals or metal alloys that the interconnection elements 22 may be made of include Sn with a melting temperature of 232°C, SnAgCu with a melting temperature of 217°C, SnAg with a melting temperature of 221°C, SnCu with a melting temperature of 227°C, or SnPb eutectic with a melting temperature of 183°C. The chuck 20 is used to place the microelectronic die 18 on the substrate 10 (215), the interconnection elements 22 are inserted into the no-flow underfill material 16, and each interconnection element 22 comes into contact with a respective one of the substrate terminals 14. The no-flow underfill material 16 is still at approximately 60°C. The microelectronic die 18 and the interconnection elements 22 are at a temperature of approximately 22°C.

Because the no-flow underfill material 18 has been preheated, it wets more easily over surfaces of the microelectronic die 18 and the interconnection elements 22.

[0021] As illustrated in Figure 1D, the interconnection elements 22 are subsequently reflowed for purposes of joint formation between the interconnection elements 22 and in substrate terminals 14 (220). The interconnection elements 22 are heated to above their melting temperatures, and subsequently allowed to cool. The chuck 20 holds the microelectronic die 18 so that the microelectronic die 18 does not collapse onto the substrate 10 when the interconnection elements 22 are being heated. The chuck 20 also provides a small downward force in a direction of the substrate 10. The interconnection elements 22 are thus soldered to the substrate terminals 14. The no-flow underfill material 16 acts as a solder flux that removes metal oxides from the interconnection elements 22 when they are heated. A more

reliable joint is thereby formed between each interconnection element 22 and a respective substrate terminal 14.

[0022] Reference is now made to Figure 1E. The chuck 20 illustrated in Figure 1D has been removed from the microelectronic die 18. The entire assembly is then heated to a temperature and for a period of time sufficient to cure the no-flow underfill material 16 (225). Curing of the no-flow underfill material 16 hardens the no-flow underfill material 16. When the integrated circuit in the microelectronic die is operated, heat is generated by the integrated circuit and distributed throughout the entire assembly. Stresses are created due to differences in coefficients of thermal expansion of the microelectronic die 18 and the substrate. These stresses are particularly large on the interconnection elements 22 and may tend to shear the interconnection elements 22 from the substrate terminals 14. The hardened no-flow underfill material 16 distributes stresses due to differences in coefficients of thermal expansion between the microelectronic die 18 and the substrate 10.

[0023] Figures 3A to 3E and corresponding Figure 4 illustrate a method (400) of making a microelectronic assembly according to another embodiment of the invention. As illustrated in Figure 3A, a no-flow underfill material 16 is dispensed out of a dispensing apparatus 12 onto a substrate 10 (405). The no-flow underfill material 16 and the substrate 10 are both at approximately 22°C. As illustrated in Figure 3B, a chuck 20 is used to place a microelectronic die 18 onto a substrate 10 (410). Interconnection elements 22 come into contact with substrate terminals 14 on

the substrate 10. The microelectronic die 18 and the interconnection elements 22 are also at approximately 22°C.

[0024] Reference is now made to Figure 3D. The chuck 20 of Figure 3D is removed from the microelectronic die 18. The entire assembly is then preheated to promote flow and wetting of the no-flow underfill material (415). The assembly is heated to approximately 60°C. In another embodiment, the assembly may be heated to a temperature between 30°C and 120°C.

[0025] Referring to Figure 3C, the microelectronic die 18 is again held by the chuck 20 and the entire assembly is heated to above the melting temperature of the interconnection elements 22 to reflow the interconnection elements for joint formation (420). Subsequent cooling of the assembly causes solidification of the interconnection elements 22 and attachment of the interconnection elements 22 to the substrate terminals 14.

[0026] As illustrated in Figure 3E, the chuck 20 of Figure 3C is removed from the microelectronic die 18. As also illustrated, the entire assembly is then heated to a temperature and for a period of time sufficient to cure the no-flow underfill material 16 (425).

[0027] Figures 5A to 5E and corresponding Figure 6 illustrate a method 600 of making a microelectronic assembly according to a further embodiment of the invention. As illustrated in Figure 5A, a no-flow underfill material 16 is dispensed onto a surface of a microelectronic die 18 (605). The no-flow underfill material 16 is dispensed out of a dispensing apparatus 12 at approximately 22°C onto the die 18

which is also at approximately 22°C. The no-flow underfill material 16 is then located between interconnection elements 22 on the microelectronic die 18.

[0028] As illustrated in Figure 5B, a substrate 10 is placed on the die 18 (610). A plurality of substrate terminals 14 are formed on the substrate 10. Each substrate terminal 14 comes into contact with a respective one of the interconnection elements 22. A chuck 20 is used to move the substrate 10 onto the die 18.

[0029] Reference is now made to Figure 5C. The chuck 20 of Figure 5B is removed. The entire assembly is subsequently preheated to promote flow and wetting of the underfill material 16 (615). The preheat temperature is approximately 60°C. In another embodiment, the preheat temperature may be between 30°C and 120°C.

[0030] Reference is now made to Figure 5D. The assembly of Figure 5C is flipped so that the microelectronic die 18 is at the top. The chuck 20 is then connected to the microelectronic die 18. The entire assembly is then heated to a temperature above the melting temperatures of the interconnection elements 22 to cause reflow of the interconnection elements for joint formation (620). The chuck 20 remains connected to the microelectronic die 18 until the assembly is allowed to cool to a temperature wherein the interconnection elements 22 are again solid.

[0031] Reference is now made to Figure 5E. The chuck 20 of Figure 5D is subsequently removed. The entire assembly is then heated to a temperature and for a time sufficient to cure the no-flow underfill material (625).

[0032] While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative and not restrictive of the current invention, and that this invention is not restricted to the specific constructions and arrangements shown and described since modifications may occur to those ordinarily skilled in the art.